NOAA Testbeds and Proving Grounds Workshop
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Testing and evaluation of physical parameterization innovations for NOAA's Next-Generation Global Prediction System

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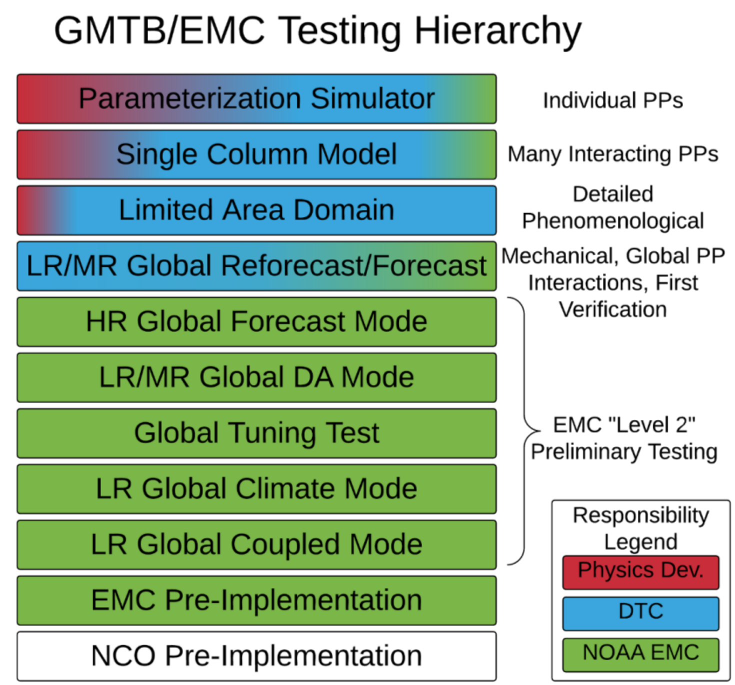
[*]Developmental Testbed Center

Developmental Testbed Center

GMTB is funded by the NOAA Next-Generation Global Prediction System to foster community involvement in the development of NCEP's global prediction systems

GMTB activities



1. **Development and maintenance of testing infrastructure**
   - Single column model, global workflow, verification, diagnostics
2. **Testing and evaluation**
3. **Common Community Physics Package**
   - A collection of physical parameterizations, grouped in suites, that can be used with multiple dynamic cores
   - A framework that enables collaborative development and R2O

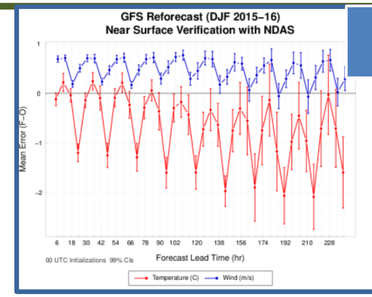
(Re)forecast workflow description

Workflow supplied by NOAA EMC

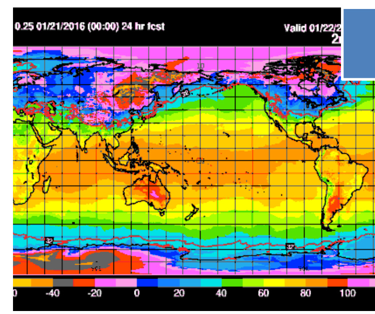
Initialization Datasets → Preproc → Forecast → Postproc →

Workflow developed by GMTB

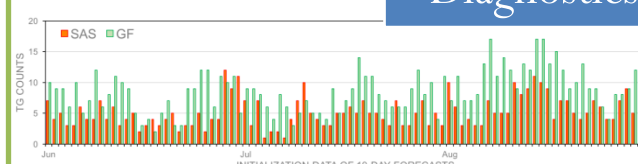
Verification



Graphics



Diagnostics



Complementary workflows

EMC workflow

- GMTB keeping pace with EMC procedures
- GMTB/EMC collaborate to resolve issues on both sides

GMTB workflow

- Highly flexible and configurable
- EMC verification methods in DTC's **Model Evaluation Tools (MET)**

Test of Grell-Freitas Cu scheme in GFS

Test plan created jointly with EMC, NGGPS Program Office, and developer (G. Grell)

SCM

Cu	Res (km)	Run by	IC	Period
GF	~34	GMTB	GEWEX Tropical Warm Pool Summer case	1 field campaign
SAS				

Global

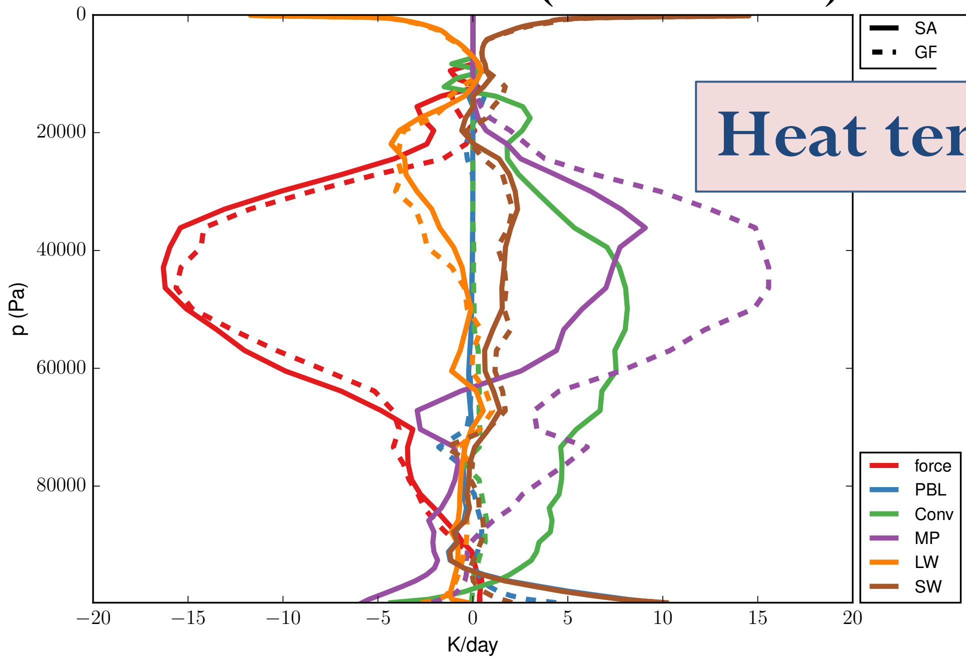
Cu	Res (km)	Run by	IC	Period
GF	~34	GMTB	Operational GFS analyses	JJA 2016
SAS				

Connecting GF to GFS correctly was a multi-month iterative process with developer – effort should not be underestimated!

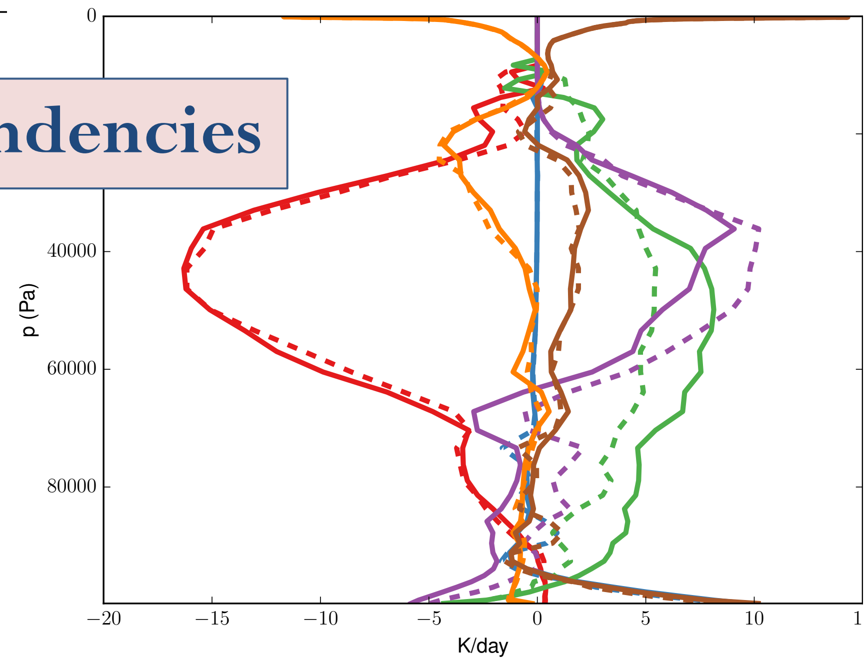
http://www.dtcenter.org/GMTB/gmtb_scm_doc/

SCM: tool to quickly identify code issues

Grell-Freitas r84921 (older version)



Grell-Freitas r85909 (current version)



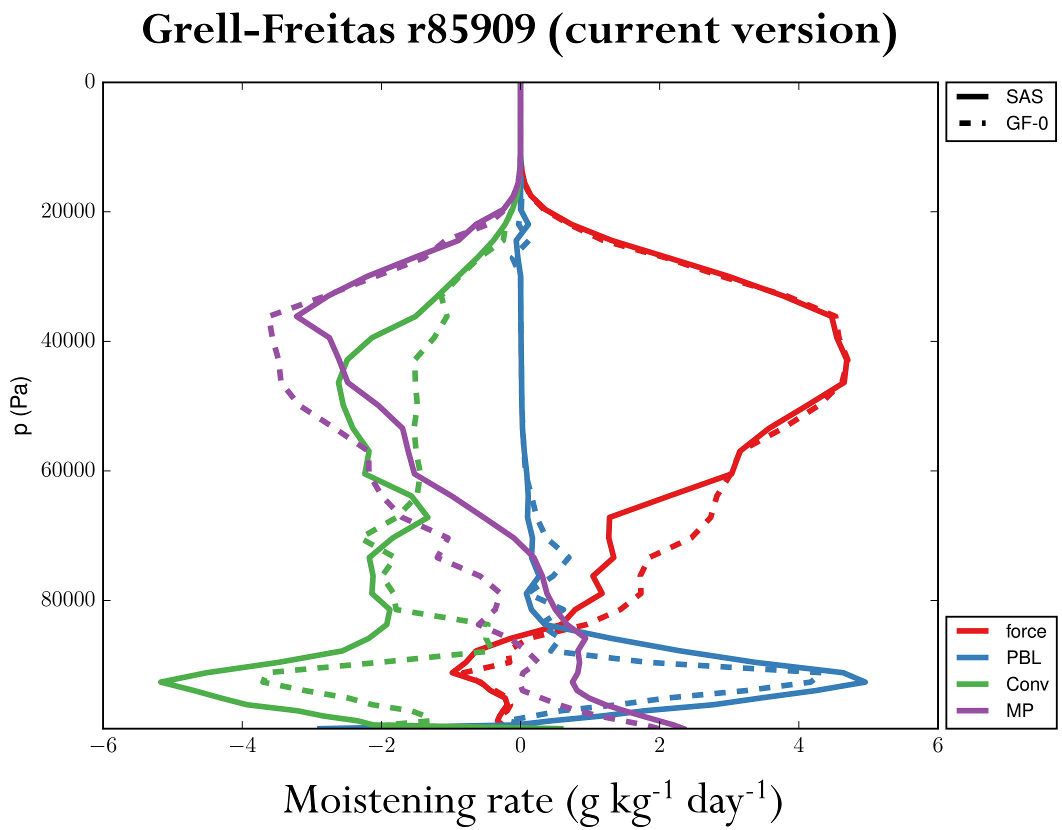
Heat tendencies

Problem in GF code identified using SCM, led to fix by developer:

Erroneous near zero deep convection (dashed green line) in implemented GF code http://www.dtcenter.org/GMTB/gmtb_scm_doc/

SCM: tool to understand physics suite

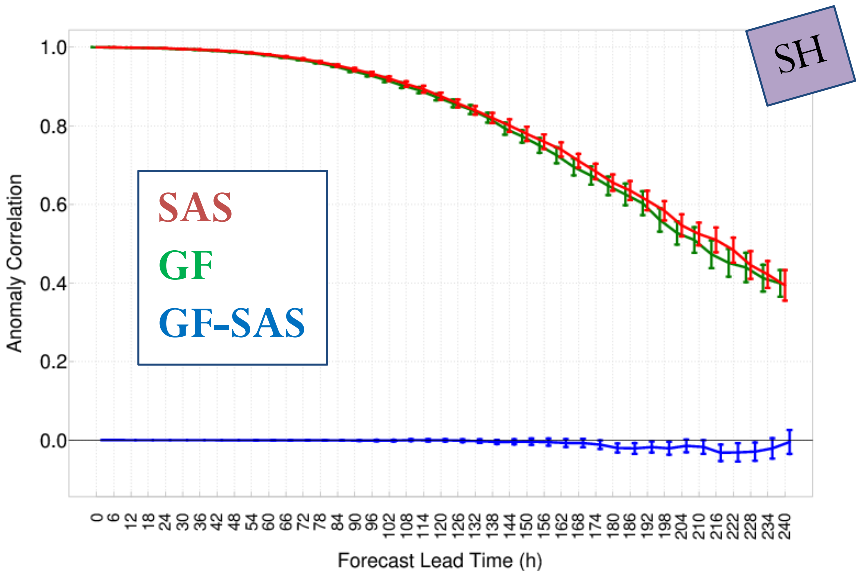
Vapor tendencies

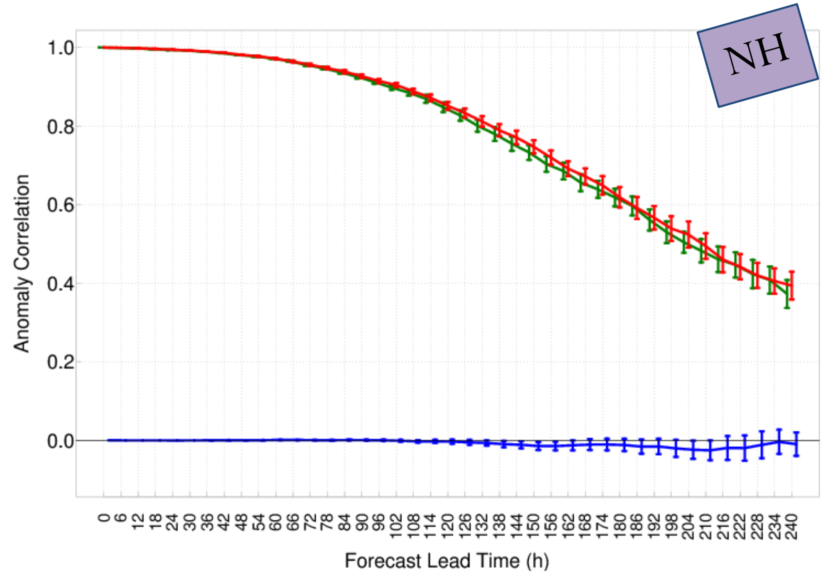


Partition between convection and microphysics: in runs with GF, microphysics play a larger role

Low level equilibrium between convective drying and boundary layer moistening: larger extremes in runs with SAS

500 hPa height anomaly correlation





S Hemisphere: GF has statistically significant lower AC for a few lead times later in forecast period (but by then AC below usable 0.6)

N Hemisphere: SAS and GF similar

Quite similar results between the two model configurations

Better configuration depends on variable, level, and lead time

NH JJA 2016 Score card: p-values show statistical differences

			f12	f24	f36	f48	f60	f72	f84	f96	f108	f120	f132	f144	f156	f168	f180	f192	f204	f216	f228	f240
Bias	Temp	P100	▼-1.000	▼-1.000	▼-1.000	▲1.000	▼-1.000	▲1.000	▼-1.000	▲1.000	▼-1.000	▲1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▲1.000	▼-1.000	▲1.000	▼-1.000	▼-1.000
		P150	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-0.999	▼-0.995	▼-0.999	-0.978	▼-0.992	-0.865	-0.934	-0.794	-0.919	-0.728	-0.693	-0.658	-0.865	-0.728	-0.829
		P200	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000
		P300	▼-1.000	0.874	0.872	0.855	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▲1.000	▼-1.000	▲1.000	▲1.000	▲1.000	▲1.000
		P400	▼-1.000	▲1.000	▲0.999	▲1.000	0.955	0.958	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000
		P500	▼-1.000	0.687	-0.982	▲1.000	-0.657	0.936	▼-1.000	▲0.997	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000
		P700	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000
		P850	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000
	RH	P300	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲0.998	▲1.000	▲1.000	▲1.000
		P400	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲0.999	▲1.000	▲1.000	▲1.000	▲0.994	0.983	0.938	▲0.998	0.920	▲0.992	0.797	0.755	0.716	▲0.999
		P500	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲0.999	▲1.000	▲0.993	▲1.000	0.969	▲0.999	0.950	0.904	0.664	▲0.999
		P700	▼-1.000	▼-1.000	▼-1.000	▲1.000	▼-1.000	▲1.000	▼-1.000	▲1.000	▼-1.000	▲1.000	▲1.000	▲1.000	▼-1.000	▲1.000	▼-1.000	▲0.999	▼-1.000	▲0.999	▼-1.000	▼-0.995
		P850	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000
	Wind	P100	▲1.000	▼-1.000	▲1.000	▼-1.000	▲1.000	▼-1.000	0.728	▼-1.000	0.546	-0.987	0.766	-0.788	0.930	-0.135	0.736	-0.560	0.900	-0.228	0.832	-0.872
		P150	▼-1.000	-0.386	▼-1.000	0.843	▼-1.000	▼-0.995	▼-1.000	▼-1.000	▼-1.000	-0.988	▼-1.000	-0.965	▼-1.000	-0.502	▼-1.000	-0.520	▼-0.999	-0.632	▼-1.000	-0.967
		P200	▼-1.000	0.793	▼-1.000	0.948	▼-1.000	-0.979	▼-1.000	▼-0.999	▼-1.000	-0.885	▼-1.000	-0.819	▼-1.000	-0.279	▼-0.998	0.373	-0.939	-0.215	▼-1.000	-0.427
		P300	▼-0.994	▲0.999	0.972	▲1.000	0.898	▲0.992	-0.507	0.873	-0.212	0.964	0.036	0.853	0.254	▲0.992	0.242	▲0.999	0.964	0.979	-0.140	0.971
		P400	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲0.998	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	0.973	▲0.997
		P500	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲0.991	▲1.000
		P700	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲0.999	0.639	0.208	-0.572	0.492	-0.675	0.947	-0.976	-0.545	-0.984	-0.693	▼-0.990	-0.902	▼-0.993	-0.719
		P850	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	0.128	0.803	-0.961	0.749	-0.966	-0.142	▼-1.000	-0.958	▼-1.000	▼-0.999	▼-1.000	▼-0.999	▼-1.000	▼-0.999
RMSE	Temp	P100	-0.976	▼-1.000	▼-1.000	▼-0.999	▼-0.999	▼-1.000	▼-1.000	-0.695	▼-0.995	-0.883	-0.986	-0.894	-0.789	-0.355	0.614	0.640	0.857	0.903	0.980	0.949
		P150	0.018	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	-0.806	-0.975	-0.814	▼-0.997	-0.665	-0.963	-0.121	-0.719	0.207	0.271	0.681	0.457	0.934	0.859
		P200	0.815	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-0.998	▼-0.996	-0.967	▼-1.000	▼-0.999	▼-0.999	-0.921	-0.687	0.058	-0.289	-0.397	-0.384	-0.312	-0.179
		P300	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-0.992	▼-0.994	-0.913	-0.741	-0.757	-0.735	-0.112	0.085	0.452	0.315	0.720	0.437
		P400	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	-0.975	-0.983	-0.917	-0.983	-0.596	-0.836	-0.296	-0.642	-0.106	-0.208	0.131	-0.228	0.342	0.079
		P500	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	-0.937	-0.941	-0.841	-0.977	-0.090	-0.501	0.016	0.180	0.296	-0.071	-0.002	0.189	0.611	0.740
		P700	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	-0.989	-0.985	-0.989	-0.873	-0.874	-0.879	-0.716	-0.278	-0.301	0.355	0.713	0.786
		P850	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-0.999	▼-0.999	▼-0.997	▼-0.994	-0.882
	RH	P300	-0.487	0.956	0.604	▲1.000	▲0.993	▲1.000	▲1.000	▲1.000	▲1.000	▲1.000	▲0.994	▲1.000	▲0.998	▲1.000	0.971	▲0.999	▲0.997	▲1.000	▲1.000	▲1.000
		P400	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-0.993	▼-1.000	-0.101	-0.266	0.803	-0.514	0.843	0.099	▲0.995	0.558	0.470	0.867	0.472	0.291	0.901
		P500	-0.849	-0.928	▼-0.999	-0.715	-0.938	-0.961	-0.982	0.851	0.310	0.949	0.389	0.826	0.265	0.986	0.964	▲0.993	▲0.997	▲0.999	0.957	0.977
		P700	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-0.999	-0.989	-0.955	▼-0.997	-0.958	-0.574	-0.968
		P850	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000
	Wind	P100	-0.074	▼-0.999	▼-0.999	▼-0.999	0.530	-0.309	0.330	0.559	0.886	0.953	0.783	0.868	0.728	0.740	0.766	0.925	0.810	0.783	0.272	0.897
		P150	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-0.997	-0.950	▼-0.997	-0.871	-0.733	0.035	-0.266	0.484	0.882	0.746	0.933	0.647	0.876	0.628
		P200	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-0.994	-0.963	-0.891	-0.728	0.544	0.642	0.725	0.057	0.630	0.936	0.788	0.804	0.914	0.833
		P300	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-0.998	-0.970	-0.950	▼-0.995	-0.956	-0.607	-0.188	-0.570	-0.708	0.057	0.730	0.338	0.730	0.905	0.173
		P400	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	-0.941	-0.779	-0.973	-0.987	▼-0.993	-0.362	-0.431	-0.717	-0.098	0.242	0.634	0.685	0.819	0.654
		P500	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	-0.982	-0.986	-0.909	-0.972	-0.630	0.295	0.515	-0.097	0.308	0.361	0.748	0.635	0.959	0.916
		P700	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-0.999	▼-1.000	▼-0.991	-0.969	-0.062	0.557	-0.003	-0.754	0.004	0.815	0.364	0.961	0.404
		P850	▼-0.998	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	▼-1.000	-0.981	-0.836	-0.921	-0.973	-0.695	0.463	0.224	0.001	0.227

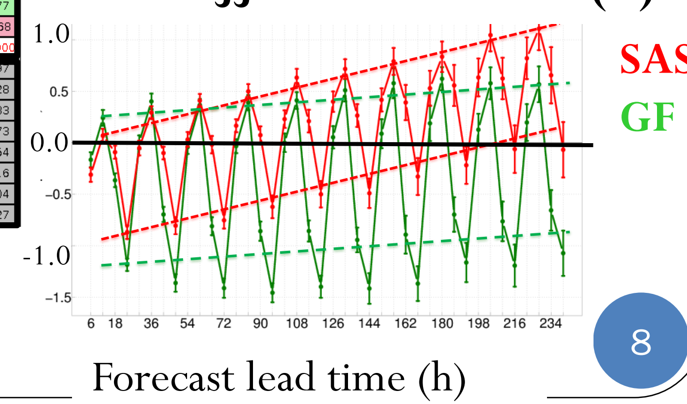
Red=SAS better

Green=GF better

▲	gftest_0p25_G3 is better than sasctrl_0p25_G3 at the 99.9% significance level
▲	gftest_0p25_G3 is better than sasctrl_0p25_G3 at the 99% significance level
	gftest_0p25_G3 is better than sasctrl_0p25_G3 at the 95% significance level
	No statistically significant difference between gftest_0p25_G3 and sasctrl_0p25_G3
	gftest_0p25_G3 is worse than sasctrl_0p25_G3 at the 95% significance level
▼	gftest_0p25_G3 is worse than sasctrl_0p25_G3 at the 99% significance level
▼	gftest_0p25_G3 is worse than sasctrl_0p25_G3 at the 99.9% significance level
	Not statistically relevant

- SS differences favor SAS
- Advantage of SAS diminishes w/ lead time, esp. for T bias
  - Points to limitation of test (no cycled DA)
- SAS T bias increases w/ lead time, particularly noticeable over land, whereas increasing trend much smaller for GF

CONUS JJA 2016 2mT bias (K)



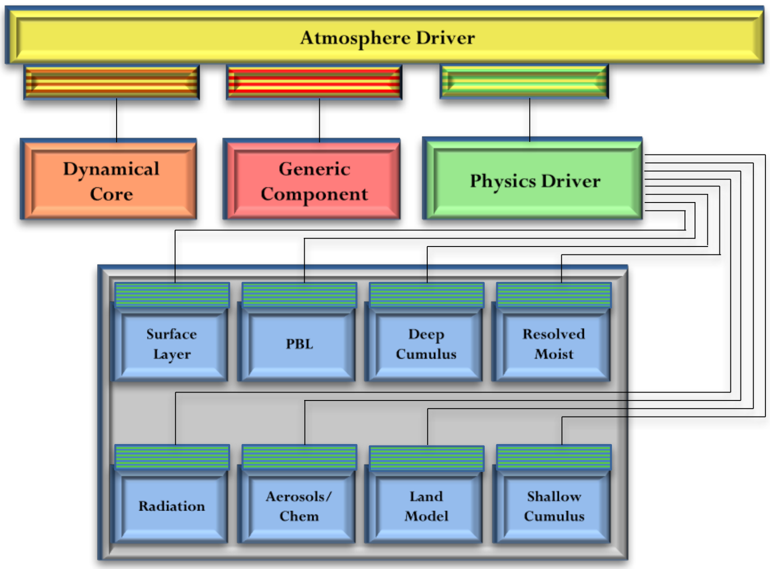
Strategy for NCEP physics evolution

NGGPS Physics Workshop (Nov 2016; 80 scientists)

- Priorities and gaps for physics advancements were put forth
  - Focus on scale awareness, stochasticity, and aerosols
- Advancement of interactions among parameterizations is key
- Need transparent, well-defined criteria for testing and adopting changes in physics
- Need a collaborative framework for experimenting and developing physical parameterizations

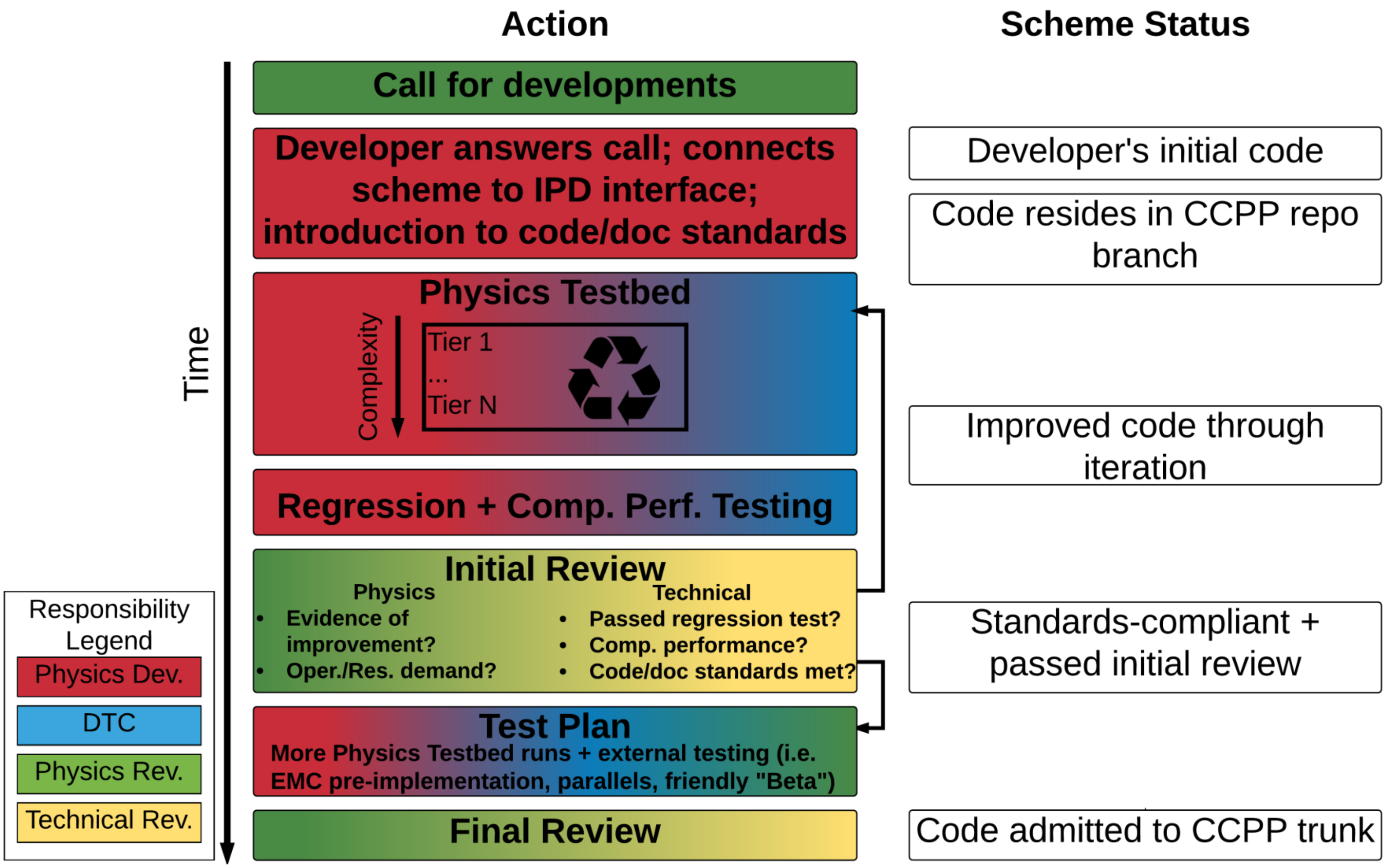
Way ahead: the Common Community Physics Package (CCPP)

A framework for community involvement in physics development. NOAA will benefit by having scientists in multiple institutions to run and develop a common set of physics



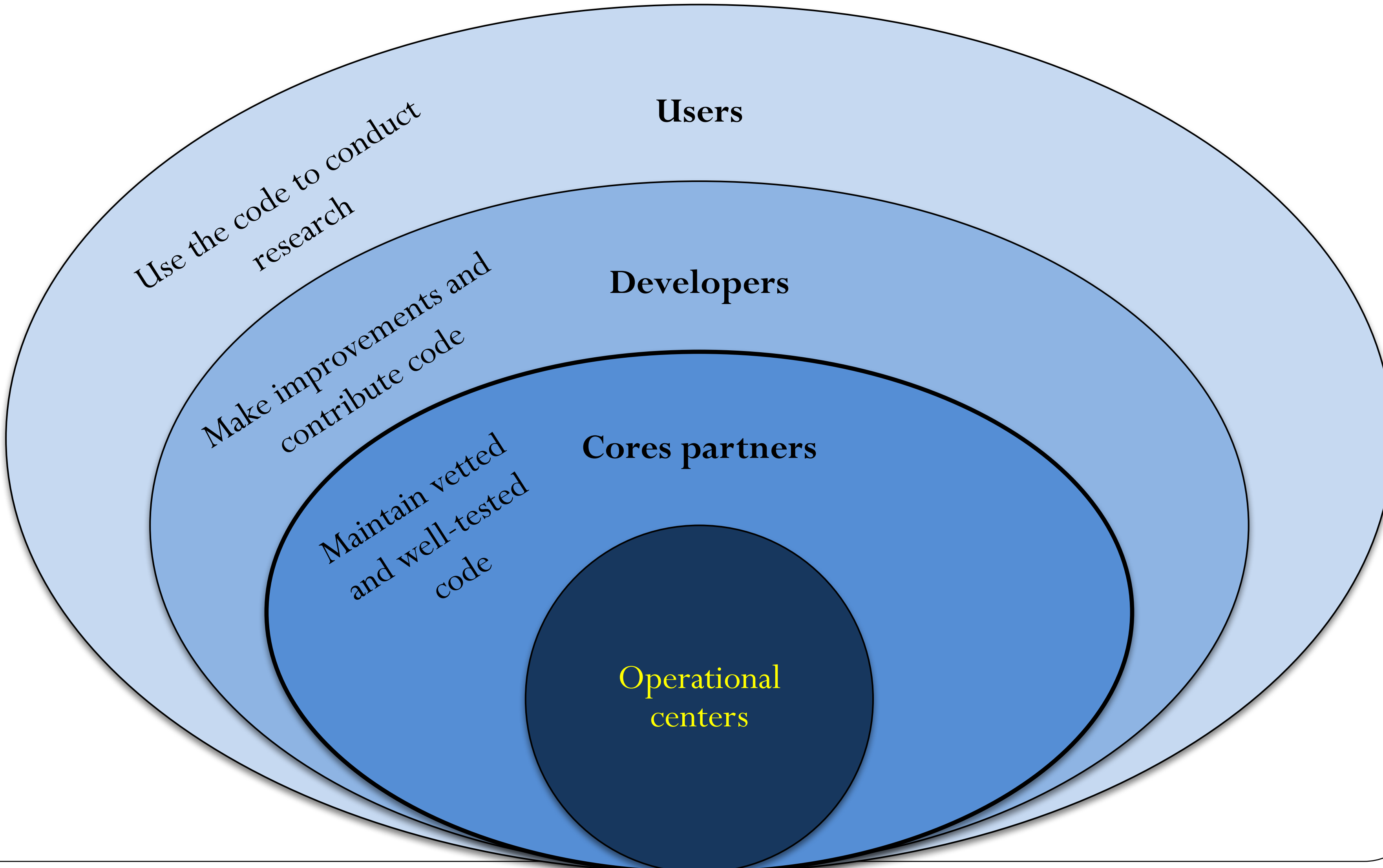
- CCPP is a collection of **dycore-agnostic**, **vetted**, physical parameterizations. There can be multiple of each type (PBL, cumulus etc.) to support various applications (high-res, climate etc.) and maturity level (operational, developmental)
- **Dycore agnostic** means that the parameterizations can be used with any dycore
- **Vetted** means that there is a process to determine what is included in CCPP at each layer

Workflow for Physics Development



CCPP Ecosystem

A single code to serve a variety of needs and facilitate R2O



Summary

- GMTB has been established to support the evolution of atmospheric physical parameterizations in NCEP global modeling applications
- A hierarchical testbed has been established and used to assess an experimental convective parameterization
- A CCPP is being created to facilitate engagement from the broad community on physics experimentation and development